MODIS DATA STUDY
TEAM PRESENTATION

June 9, 1989

AGENDA

1. Status of the MODIS Data Study.
2. Preliminary High-Level Data Flows for MODIS Level-1 Processing.
3. Data Flows for Level-1 Receive Data Function.
4. Data Flows for Level-1 Compute Observation Geometry Function.
5. Data Flows for Level-1 Generate Calibrated Radiances Function.
6. Data Flows for Level-1 Format Output Products Function.
7. Interface Between the DHC Level-0 Data Processing and the CDHF Level-1 Processing.
8. Interface Between the DHC Ancillary Data Processing and the CDHF Level-1 Processing.
9. Space-Based Motion Sensor Design.

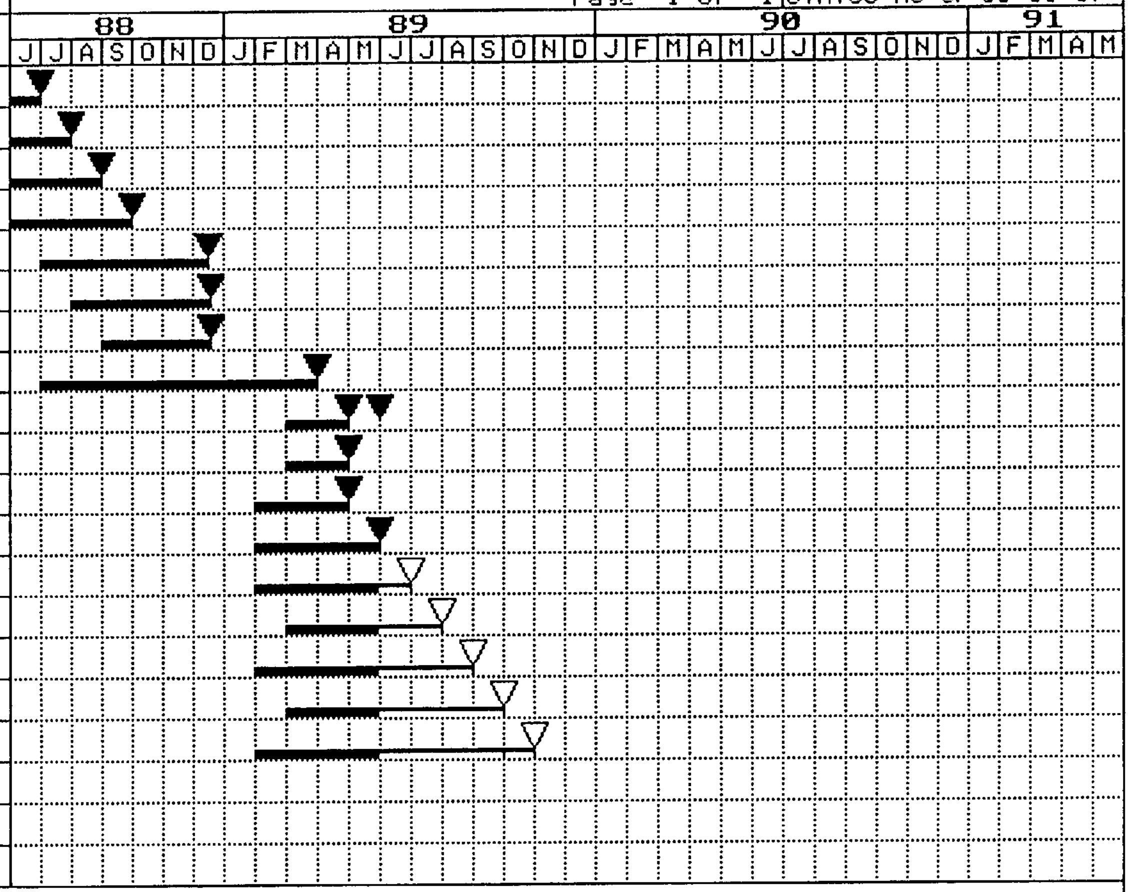
MODIS DATA SYSTEM STUDY
APPROVAL
ACCOMP.

Summary of Deliverables

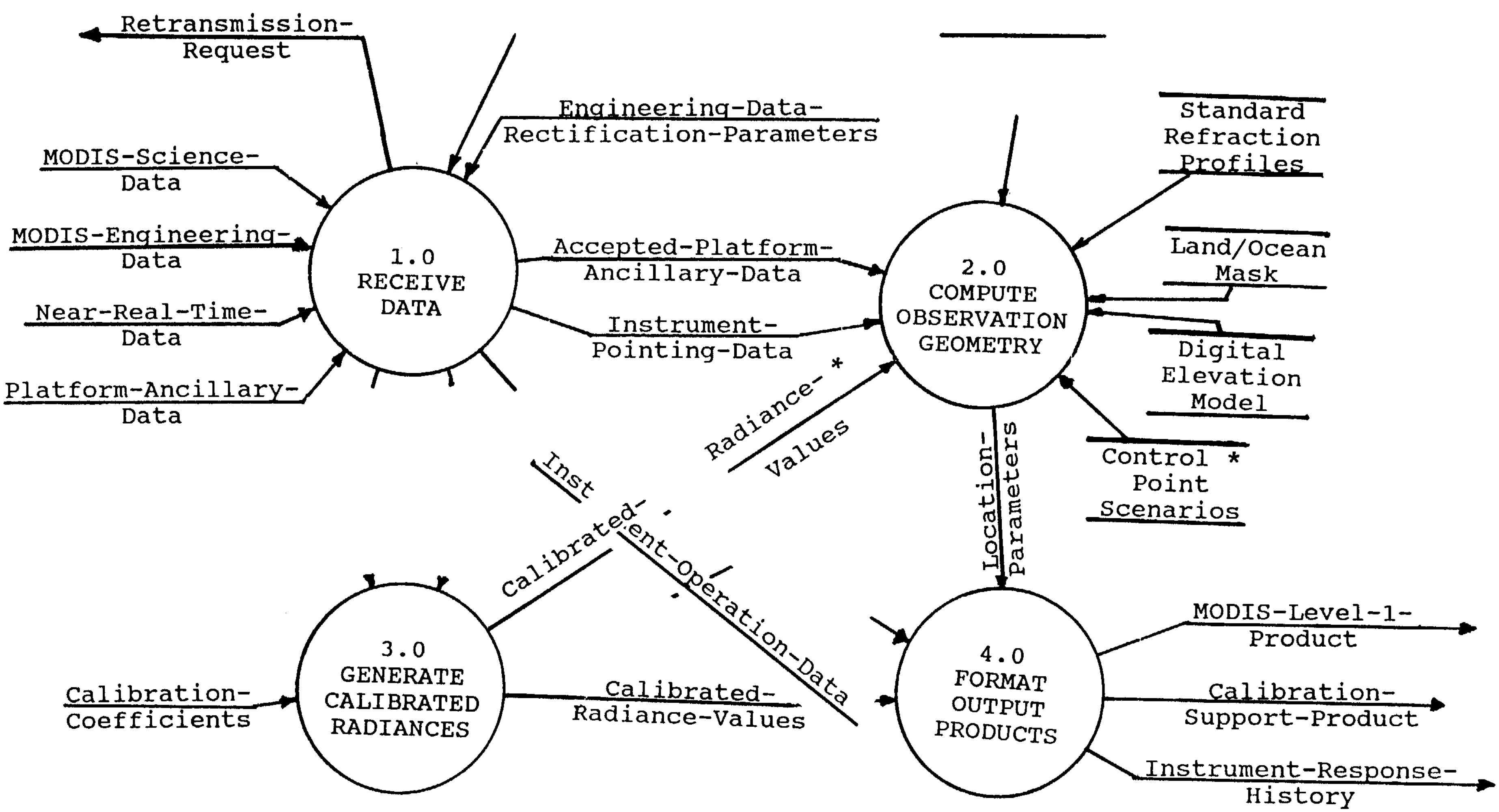
Page 1 of 1

ORIG. APPVL. 06/24/88
LAST CHANGE 05/01/89
STATUS AS OF 06/01/89

	MILESTONES
01	WBS Study Plans
02	Prelim User Data Prod Req'ts
03	Preliminary Operations Concept
04	Functional Requirements Doc
05	Prelim Data Processing Plan
06	Prelim System Specification
07	Operations Concept
08	Prelim Data Requirements Doc
09	Non-Advoc'y Rev'w Mat'ls
10	EosDIS/MIDACS I/F Comparison
11	Scenarios for Science Team
12	Prel TM Sci Product Summary
13	Input Data Attributes Report
14	MODIS Data Prod Algorithm Rep
15	TM Product Analysis Report
16	MODIS SDST/ICT Req'ts Doc
17	Data Requirements Doc
18	
19	
20	

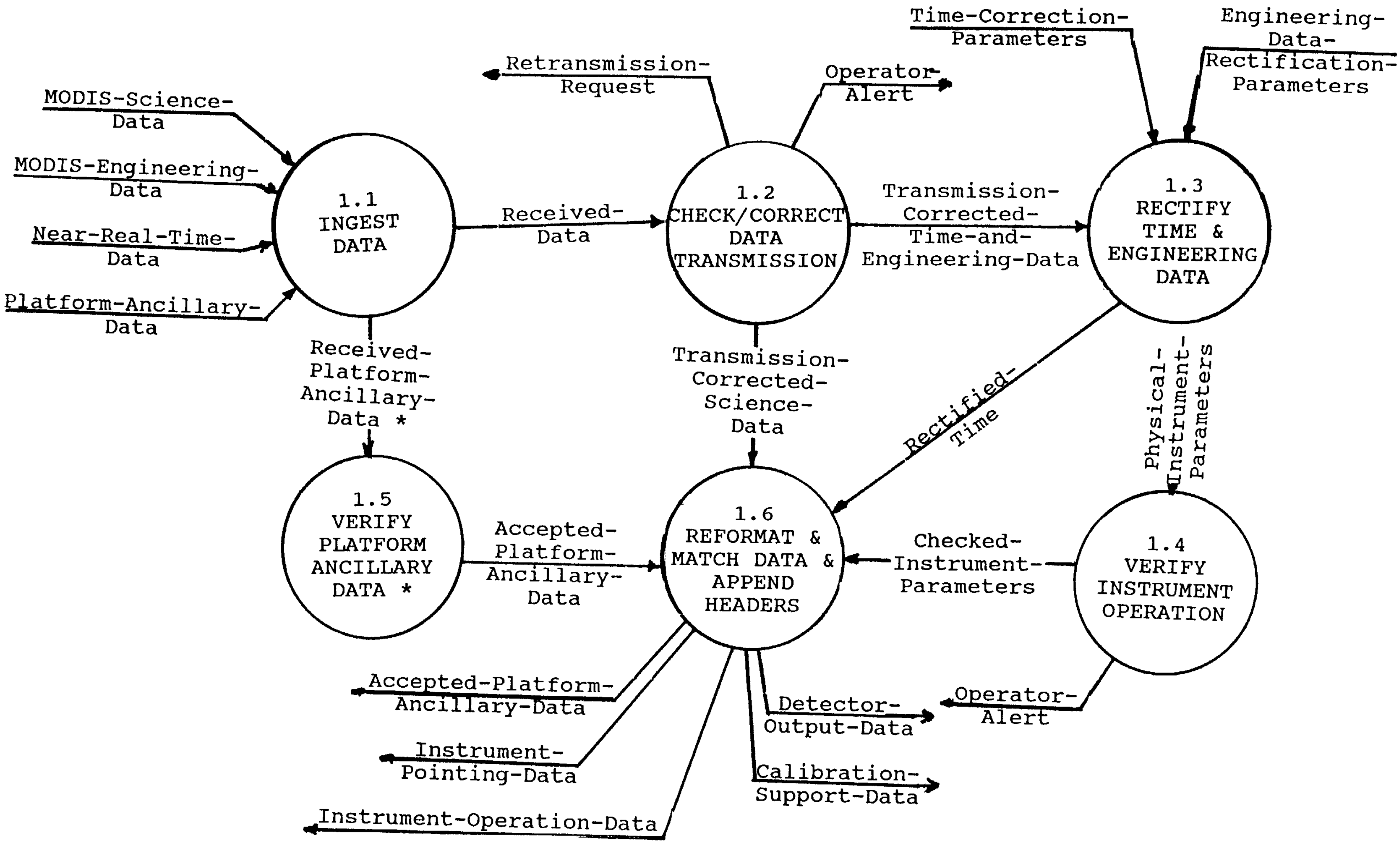


Note:



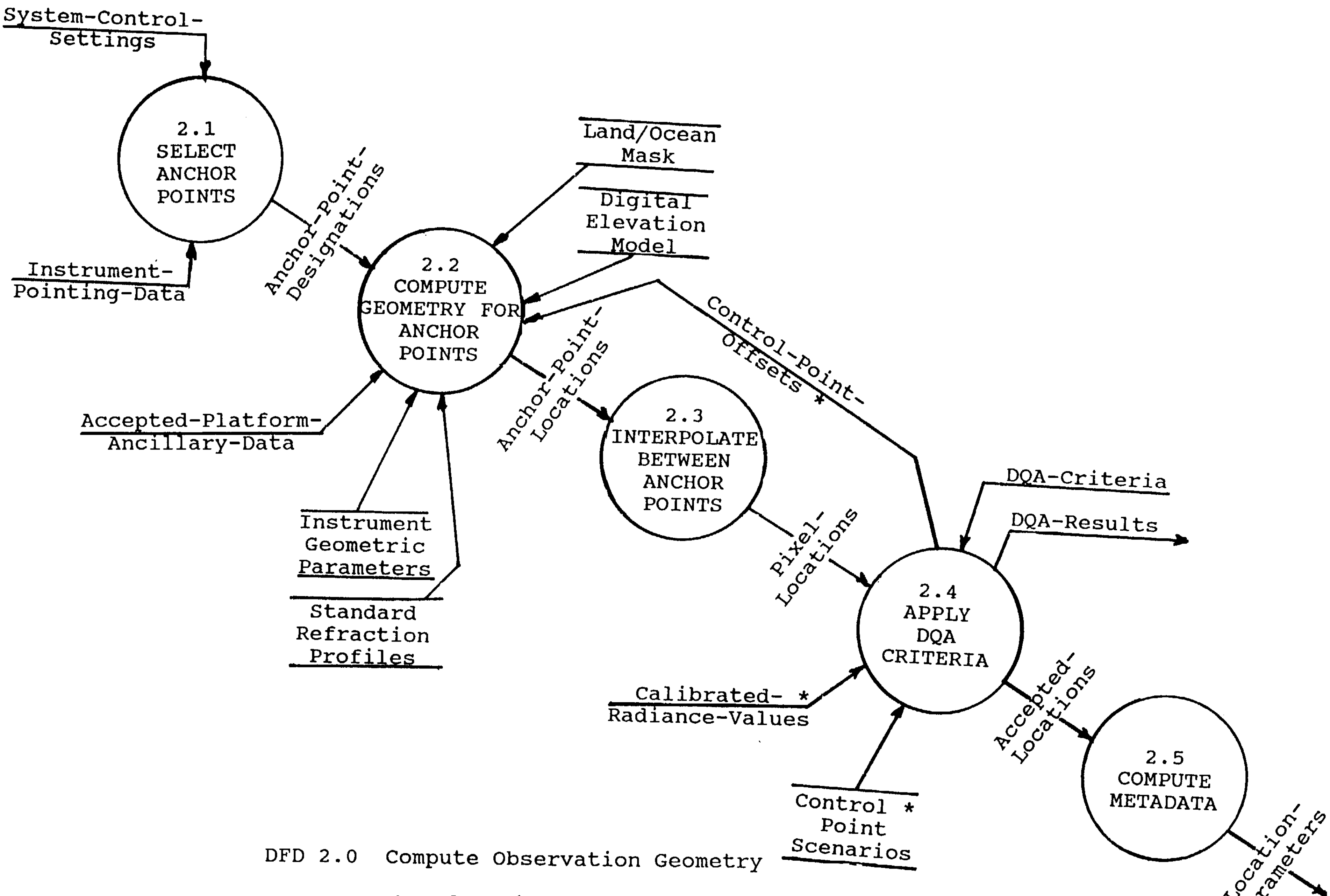
MODIS-Unique Level-1 Processing

* Under discussion



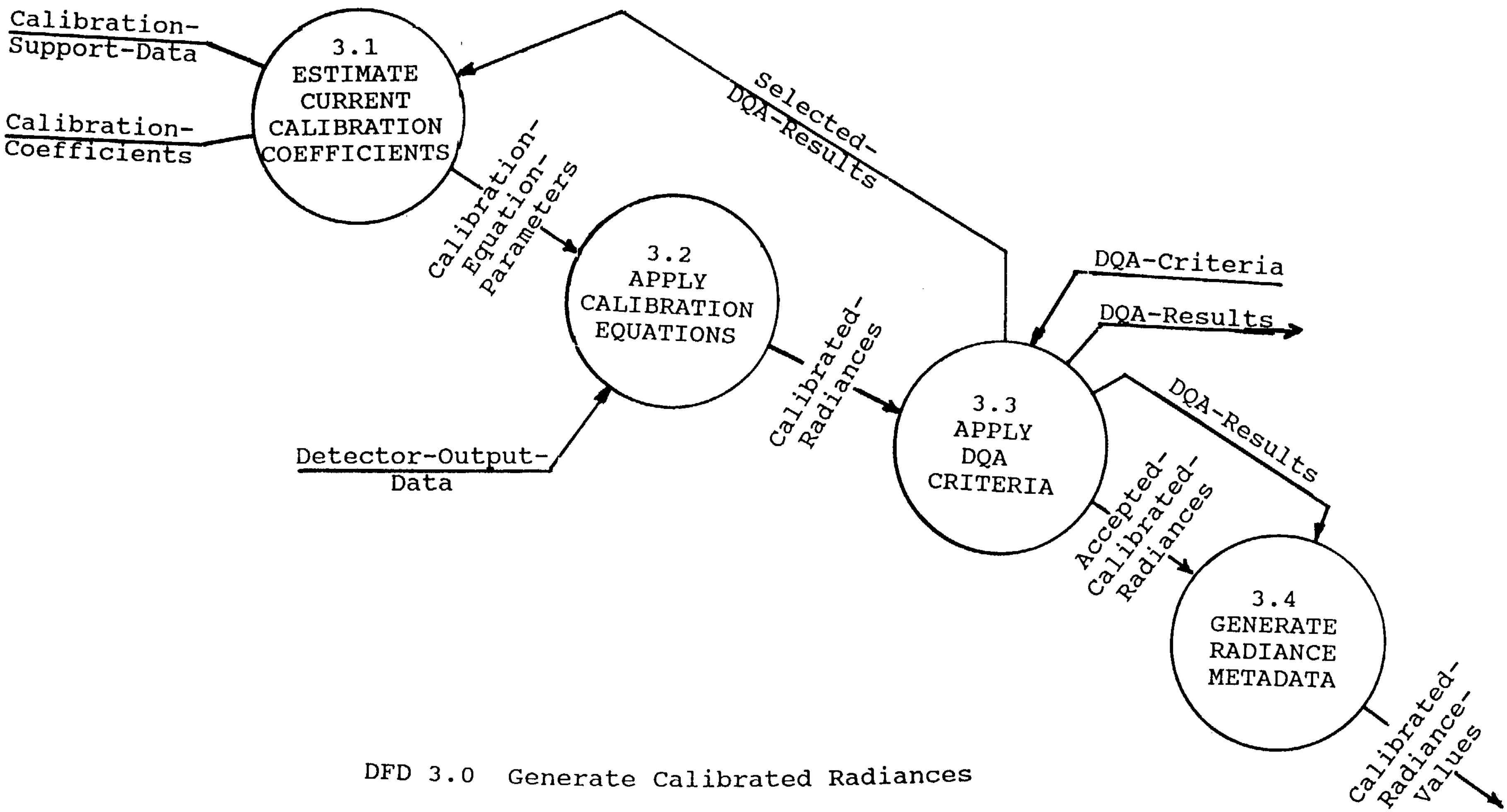
DFD 1.0 Receive Data

* Presumes Platform-Ancillary-Data received from DHC.

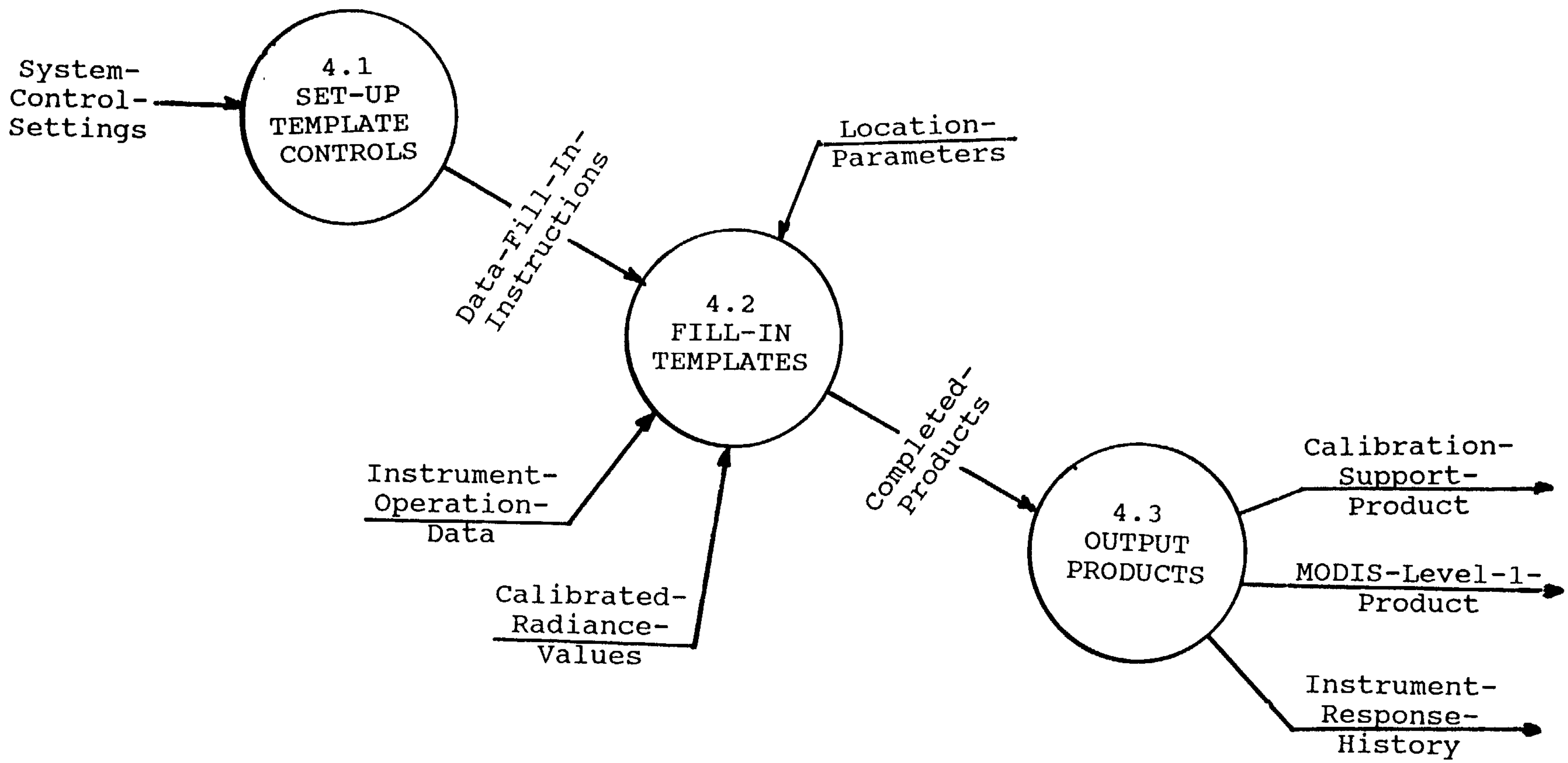


DFD 2.0 Compute Observation Geometry

* Under discussion



DFD 3.0 Generate Calibrated Radiances



DFD 4.0 Format Output Products

2. DHC LEVEL-0 / CDHF LEVEL-1 PROCESSING

2.1 Interface Summary

An interface is required for processed Level-0 data to be passed to the CDHF for the generation of Level-1 data. The source of this interface will be the DHC. The DHC will Level-0 process the data and make it available within 24 hours from time of receipt. This section presents the characteristics of the Level-0 data that passes from the DHC to the CDHF and related transmission attributes.

2.2.1 DHC Level-0 Data

Level-0 data is defined here as MODIS instrument data at original resolution, time ordered restored, with duplicates removed.

2.2.1 Data Content

Level-0 MODIS data processed by the DHC is transmitted to the MODIS ground data system (CDHF) as science data packets. These packets contain MODIS science data, MODIS engineering data, and other MODIS instrument ancillary data. Science data is the output from the MODIS detector array while observing the Earth. MODIS engineering data are data produced by the instrument engineering sensors for instrument control or to support processing science data. Engineering data is sometimes called housekeeping data and may include temperatures, operation information, etc. MODIS ancillary data is data that is specifically included in a data packet, but is not generated by the MODIS instrument. Ancillary data may include GPS derived orbit and platform attitude data at tagged epochs.

Messages and associated responses with respect to the DHC level-0 processing are also sent, but will be discussed under a separate report heading.

2.2.2 Interface Physical Description

The interface between the DHC and the MODIS CDHF may be over TBD (T1, T2, T3, and future service?) NASCOM communication services and shall conform to the specifications in NASCOM references.

If the DHC and the CDHF are collocated, fiber optic lines currently exist which may provide an inexpensive high data rate capability.

2.2.3 Data Format

When enabled, the Level-0 data stream is transmitted to the MODIS CDHF using CCSDS standardized packets. The CCSDS has published detailed definitions of packet data structures. Their documents should be reviewed for a correct understanding of the basis for DHC operations. The CCSDS packets consist of: a standard header to provide identification, sequence, and packet information which is 48 bits in length, a user-determined source data field of variable bit length, and optional error control field of variable bit length. The total length of each packet is a maximum of TBD (8192) bits. The DHC will recreate the original MODIS data stream in the order it was generated on board the spacecraft. Format of the MODIS science data within the allocated packet position is TBD.

2.2.4 Data Rates and Volumes

Level-0 transmission data rates will depend upon the NASCOM capability at the time of application. Data sent across the NASCOM communication lines utilize the NASCOM T1, T2, and T3 lines of 1.544 Mbps, 6.176 and 43.232 Mbps/TBD respectively. Due to the anticipated high volume of 1 Terabit/day of MODIS instrument data, a high data rate, such as 300 Mbps which is equivalent to the DHC input data rates, will be required for this link.

2.2.5 Data Schedules and timelines

MODIS instrument data will be downlinked during a previously scheduled TDRS contact through the DIF which transmits the data to the DHC. This will routinely occur every orbit. DHC Level-0 processed MODIS science data will be transmitted to the CDHF at intervals up to 24 hours. That is, observed data may be at least 24 hours old when transmitted.

2.2.6 Data Transfer Method

Level-0 processed data will be transmitted via electronic methods and conform to the NASCOM specifications and related NASCOM ICDs.

2.2.7 Data Storage and Access

Level-0 data will be temporarily stored at the DHC for 2 days to facilitate a request for a retransmission of data which may have failed. The data distribution service of the DHC provides an interface between the Level-0 process and remote sites via an interface to NASCOM. Other networks for data transmission and communication may be used in place of NASCOM.

3. DHC ANCILLARY DATA / CDHF LEVEL-1 PROCESSING

3.1 Interface Summary

An interface is required for ancillary data to be passed to the CDHF for the generation of Level-1 data. The source of this interface will be the DHC. The DHC will Level-0 process ancillary data and make it available within 24 hours from time of receipt. This section presents the characteristics of the Ancillary data that passes from the DHC to the CDHF and expected transmission .

3.2 DHC Ancillary data

3.2.1 Data Content

Spacecraft ancillary data as defined by the DHC is as follows: ancillary data is data available on-board a platform, derived from platform parameters, or resulting from the onboard substitution of backup parameters, but not produced by the MODIS instrument, which are needed for the processing or interpretation of instrument data.

Spacecraft ancillary data comprises data referred to as "engineering", "core housekeeping", or "subsystem" data and includes parameters such as orbit position and velocity, attitude and rates, time, temperatures, pressures, maneuver information, internally produced magnetic fields, and other environmental measurements.

Platform ancillary data are downlinked in separate data packets which are then level-0 processed by the DHC and refined and/or repaired by the Flight Dynamics Facility.

3.2.2 Interface Physical Description

The interface between the DHC and the MODIS CDHF is over (T1, T3, future service ?) NASCOM communication services and shall conform to the specifications in NASCOM references.

3.2.3 Data Format

Ancillary data is transmitted to the MODIS CDHF using CCSDS standardized packets which are similar to the Level-0 transmission packets. The CCSDS has published detailed definitions of packet data structures and their documents. The CCSDS packets consist of: a standard header to provide identification, sequence, and packet information which is 48 bits in length, a user-determined source data field of variable bit length, and optional error control field of variable bit length. The total length of each packet is a maximum of TBD (8192 ?) bits. The DHC will recreate the original MODIS data stream in the order it was generated onboard the spacecraft. Format of the ancillary data in the packet is TBD.

3.2.4 Data Rates and Volumes

Transmission data rates of ancillary data will depend upon the NASCOM capability at the time of application. Data sent across the NASCOM communication lines may utilize the NASCOM T1, T2, and T3 lines. The volume of ancillary data transmitted by the DHC every 24 hours is estimated to be approximately 100 Megabits, based on 10^^-4 times the Level-0 data volume.

3.2.5 Data Schedules and Timelines

MODIS ancillary data will be downlinked during an available TDRS contact through the DIF and passed to the DHC every orbit on a routine schedule. DHC Level-0 processed MODIS ancillary data will be transmitted to the CDHF ground data system at intervals up to 24 hours. That is, ancillary data will be at least 24 hours old when transmitted, but will correspond in time to the Level-0 processed data. Refined or repaired ancillary data packets may be several days old.

3.2.6 Data Transfer Method

Ancillary data will be transmitted via electronic methods and conform to the NASCOM specifications and NASCOM ICDs.

3.2.7 Data Storage and Access

Ancillary will be stored at the DHC for up to two years. After which, it will be permanently archived. The Interactive Ancillary Database System of the DHC will be used to transmit the data. Ancillary data may also be access directly by utilizing the DHC IAD.

Ball Aerospace Stresses Simplicity In Space-Based Motion Sensor Design

WILLIAM B. SCOTT/BOULDER, COLO.

Ball Aerospace Systems is developing a sensor capable of remotely measuring extremely small movements in large flexible structures such as the space station's solar arrays and space-based radar systems.

Linked with an appropriate feedback and control system, the sensor also could ensure precise pointing of instruments mounted on orbiting strategic satellites and defense systems.

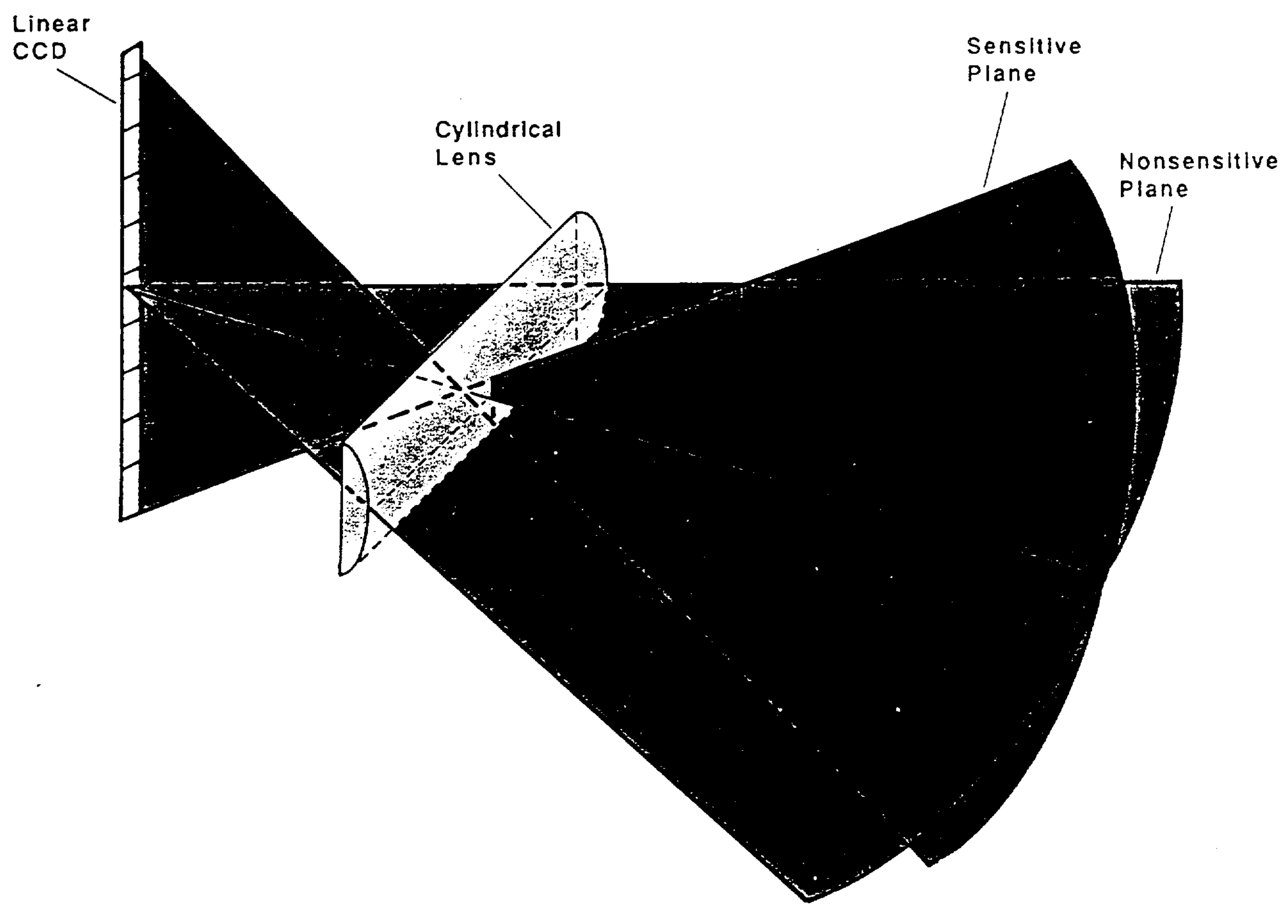
The need for accurate motion sensors has evolved as spacecraft size has increased. To meet launch weight constraints, these vehicles now are departing from the rigid platform designs used in the past. Large space structures are being adopted for a number of planned applications. Many will be lightweight, flexible designs compatible with the shuttle and available boosters.

Researchers are studying how these delicate networks of beams and braces will react in space, but a lot is yet to be learned, according to industry officials. Although the weightless environment permits lattice-like structures to be built of lightweight materials, the lack of gravity and an atmosphere in orbit also changes their dynamic response to excitation. If a thin, 70-ft.-long beam in orbit receives an impulse or shock, its reaction to that input will not be naturally dampened in space like it would on Earth, where air resistance acts like a shock absorber. The resulting response could, at the least, preclude accurate pointing of scientific or defense sensors, and might even damage the structure if beam dynamics could not be controlled.

Researchers are studying how these delicate networks of beams and braces will react in space

These concerns have prompted detailed studies—such as the Advanced Space Structure Technology Research Experiment (Astrex) project at the Air Force Astronautics Laboratory—to characterize the effects of new propulsion systems, for example, on large composite space structures (AW&ST Feb. 20, p. 51). The Air Force facility also will evaluate instrumentation methods to measure and control the responses of these nonrigid structures. With proper monitoring and fast-reacting control systems, the flexible systems' shape and position can be maintained in real time.

Several motion monitoring and mea-



RAMS uses a lens to focus an image on a linear charge-coupled device detector. As the image moves in the vertical (red) plane pixels are stimulated, providing a measurable indication of target angular position. Movement in the horizontal plane (blue) can be detected with a second RAMS detector.

surement techniques are being investigated, such as a network of accelerometers or embedded fiber-optic lines. These often require precise orientation and a complex network of wires or fibers that are not particularly compatible with current in-space deployment schemes. They may affect the structure's dynamics. Noncontact methods, such as laser scanning, radar and interferometric devices are more desirable, but are fairly complex systems. Position data often cannot be read directly from the output of these sensors either, requiring increased processing.

Ball's Remote Attitude Measurement Sensor (RAMS) is designed to measure minute translations and rotations of numerous points on a nonrigid space structure without affecting the spacecraft's normal response. It offers a balance between simplicity, accuracy, the number of measurement points and speed, according to Hugh W. Davis, principal system engineer for Ball Aerospace's Electro-Optics/Cryogenics Div.

The RAMS concept is based on illuminating a number of reflective targets attached to a flexible structure, then focusing a target image on a single-row charge-coupled device (CCD) detector. The light source is typically a laser diode colocated with the detector, and targets are either mirrors or retroreflective tape—the same material used on highway signs to enhance their visibility at night. This tape will reflect light within about 3 deg. of the light beam's incident angle, and has negligible effects on a structure's dynamic response. In some cases, a laser diode might serve as an "active target," precluding the need for a reflective device.

Light reflected from a target is focused by a cylindrical lens, which creates a line image that can be detected by the linear CCD. Displacement of a target as the structure vibrates or shifts position causes the reflected image to move along the narrow detector, providing an indication of angular change.

The cylindrical lens and linear (single row of pixels) CCD combination is sensitive only to motion in a plane parallel to the detector. Motion perpendicular to this plane will not be detected, and is called the nonsensitive plane. Consequently, one CCD/lens assembly constitutes a single-axis displacement sensor. If two-axis measurements are required, two of these assemblies can be mounted orthogonally in the same sensor head. The same two-axis configuration also will detect rotational motion about the detectors' line of sight. In this case, retroreflective targets must be spaced appropriately to ensure adequate resolution.

A RAMS prototype using a 2048-pixel CCD detector and 106-mm. focal length cylindrical lens has demonstrated an angular resolution of 0.5 arcsec., and a translation resolution of 0.12 mm. at a range of

FILTER CENTER

LITTON INDUSTRIES recently conducted the first flight test of its new fiber-optic gyro (FOG) inertial measurement unit. The system uses tiny solid state accelerometers and weighs only 5 lb. (AW&ST Feb. 13, p. 79). It is expected to have a drift rate accuracy of approximately 1 deg./hr.

THE ARMY is evaluating a new low-light, charge coupled device camera system that uses a focusing infrared illuminator to capture high-resolution images in conditions ranging from zero ambient light to full daylight. Developed by CNVS, Inc., of Grants Pass, Ore., the model EM-30 integrates a proprietary solid state IR source with a 10 × 488-pixel sensor array and zoom optics to obtain real-time imaging at ranges up to 2,500 meters. The IR illuminator's operating wavelength is minimally affected by atmospheric absorption, according to CNVS officials. The company expects initial applications to be for helicopter and fixed-wing pilot night vision devices.

COMPTEK RESEARCH, INC., of Buffalo, N. Y., has delivered a new $3.6-million Air Situation Display System for use at the Allied Tactical Operations Center at Semback Air Base, West Germany. The system is intended to improve air surveillance and consolidate offensive and defensive air operations in a single facility. It was developed under contract to USAF's Electronic Systems Div. at Hanscom AFB, Mass. Prior to installation, the monitoring of air operations was divided between Sembach and Boerfink Air Station, which is 55 mi. away. The system consists of portable desktop terminals with color monitors for individualized data presentation. The display system is driven by software consisting of 30,000 lines of source code written in Ada.

WESTINGHOUSE, which produces the APQ-164 multimode phased array radar for the B-1B, is developing a smaller, lighter-weight version for possible application to a future update of the F-16 radar. The company displayed a mockup of the antenna at the IEEE's National Aerospace and Electronics conference in Dayton, Ohio.

THE NAVY'S A-12 cockpit will provide the pilot with three 6 × 6-in. full-color displays as well as a head-up display with a 30 × 23-deg. field of view. The bombardier/navigator in the back seat of the McDonnell Douglas/General Dynamics aircraft will have four "touch-activated" 8 × 8-in. color displays. The A-12 also will carry an infrared search and track system for the covert detection of enemy aircraft.

THE AIR FORCE'S AERONAUTICAL SYSTEMS DIV. is seeking research in high-speed optical networks that would operate in the 500-2,000 Mb./sec. The requirements defined in the Pave Pillar architecture include a sensor data distribution network (SDDN), a data exchange network and a video distribution network for advanced avionics systems in future aircraft. The development of high-speed avionics architectures beyond the fourth generation will be stalled until the networks are developed, according to the Air Force. An integrated RF/EO sensor would need extremely high-speed and bidirectional communications in the sensor/aperture domain, rather than between the sensor and signal processor, as envisioned for the SDDN. Contact John Duffy, (513) 255-2957.

EATON'S AIL SYSTEMS DIV. is developing an airborne laser warning system with company funds. The objective is to develop sensors with a 90 × 60-deg. field of view, which would be capable of determining direction to laser designators within 3 deg.

THE NAVAL AIR DEVELOPMENT CENTER plans to award a contract to Hughes Aircraft Co. for benchmark ASW studies. The effort is to study low-frequency analysis and recording (LOFAR) and directional-frequency analysis and recording (DIFAR) on a modular array processor. LOFAR and DIFAR are the sonobuoys most widely used by ASW aircraft.

A SUBMINIATURE INERTIAL MEASUREMENT UNIT using three tiny laser gyros is under development at Honeywell for possible use on Strategic Defense Initiative rail-gun projectiles. It is expected to weigh less than 6 oz. The unit, which must be able to withstand 100,000g launch forces, already has been tested at 35,000g, according to Honeywell.

3.35 meters. In practical terms, this equates to detecting motion of less than 2 mm. at a range of 40 meters.

The sensor currently can measure the position of 100 targets simultaneously, and update their locations at a 250 Hz. rate. Ball expects to increase this rate to 1 KHz. by late this year, according to Jerome C. Kollodge, manager of technology development in the company's Aerospace Systems Div. Improvements in analog processing circuitry also will reduce RAMS sensitivity to temperature and background illumination changes.

Potential space applications Ball officials have identified for RAMS include:

■ Control of flexible structures by providing displacement and motion feedback to systems that will compensate for distortion and dynamic disturbances of space station structures, such as the mobile transporter. A current concept calls for this device to be equipped with a remote manipulator arm to be used for servicing of payloads and other station hardware.

■ Calibration/alignment of payloads. RAMS data would confirm that payload instruments are properly oriented on their support structures to ensure pointing angles are both known and correct. This is especially important for Strategic Defense Initiative and deep-space scientific sensors.

■ Attitude transfer. By measuring the relative differences in attitude between an instrument payload and an inertially referenced platform, RAMS can provide data necessary to calculate the payload's corrected inertial attitude.

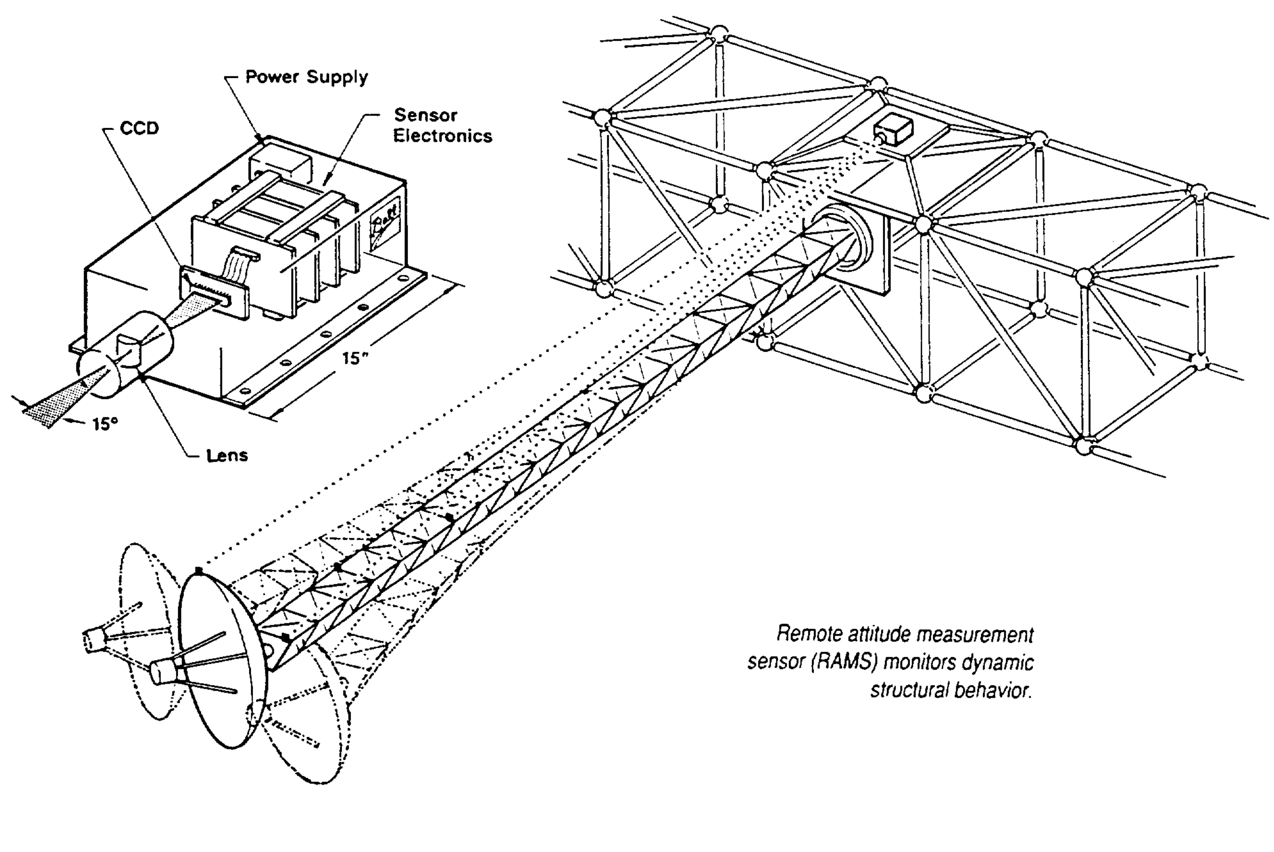
■ Surface figure measurement. By continuously monitoring the location of numerous points on the surface of a large space-based antenna, solar array or other structure, a feedback/control system can correct for distortions and maintain the proper shape or figure.

NASA has indicated it will instrument each phase of the space station as it is constructed, ensuring structural dynamics will be monitored and characterized at each step.

The remote measurement system also is a candidate for another, more near-term structural dynamics evaluation NASA is planning, he said. Called the control and structures experiment in space (CASES), the shuttle-based demonstration is similar to the Pinhole Occulter Facility that will be flown as a space station payload. The experiment involves extending a 32-meter flexible boom and "boom tip assembly" fitted with an X-ray imaging device from the shuttle cargo bay. If selected for the project, RAMS would provide displacement data for the boom and tip assembly.

A similar experiment was conducted in August, 1984, on shuttle mission 41-D using a Ball-developed retroreflector field tracker (RFT). A predecessor of RAMS, this system used five laser diodes to illuminate 23 retroreflective tape targets mounted on the surface of a large, flexible solar array panel deployed from the shuttle cargo bay. The array measured 13 ft. wide and 102 ft. long when fully extended (AW&ST Sept. 10, 1984, p. 95). Ball's RFT measured displacements of ±3 mm. with an update rate of only 6 Hz., providing in-space experience on which to base RAMS development.

The test also revealed unexpected phenomena that are being accounted for on next-generation space structures. For example, the solar array deployed on STS 41-D displayed very low frequency (0.035 Hz.), densely spaced vibrational modes and a pronounced curvature of the array during the dark portion of an orbit. □



Remote attitude measurement sensor (RAMS) monitors dynamic structural behavior.

Ball Corp.'s RAMS will monitor vibration, bending and other physical properties of large, flexible space structures. The sensor will accurately track the position of 100 target points on a structure and provide feedback signals required for active control.